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ORAL

Robotics

Decadal Survey and Strategic Knowledge Gap Science Goals with Next Generation Low Cost Small Platforms

Most of the key science priorities of the planetary science decadal survey rely on observations that involve sampling or close proximity observations of a variety of bodies. These observations address chemistry responsive to origin science and habitability as well as observational strategies for deep interior probing via internal or field geophysics. Increased interest in the reconnaissance of small bodies for Human exploration, planetary defense, and in situ resources calls for in situ chemistry and geophysics measurements as well as approaches to probe small body soil properties for geotechnical assessment. Major progress in the miniaturization of instruments and subsystems is opening the door to novel architectures for in situ observations and multi-site field measurements. High science return per dollar architectures may be approached via scalable and modular platforms to enable a range of science objectives. Following the footsteps of Earth-observing Cubesats, a number of recent concepts have been exploring the potential for Cubesats to return science grade observations at a variety of bodies, either as independent or as secondary platforms. Concepts so far cover multisite magnetic and gravity field sampling, atmospheric probing, high-resolution imaging, and strategic knowledge gap specific packages (imaging, dosimeter, dust analyzer, etc.) Low cost landers are also gaining momentum, starting with the MASCOT lander developed by the German space agency, the Hedgehog lander developed by Stanford and JPL under NASA's Center Innovation Fund, minimalistic lander concepts developed at JPL, as well as penetrators and biology inspired concepts. Key to the exploration with small platforms is the miniaturization of science grade instruments that retain high performance despite highly constrained resources and short lifetimes. Small instruments for a variety of applications are gaining maturity, especially instrumentation for geophysical probing. The development of techniques for sampling material in low gravity environment, such as laser-excited spectrometry decreases the need for mechanically heavy and power intensive sampling techniques. Algorithms for onboard data processing and triage allow increasing the science value per bit and can help select observation and sampling sites when conditions limit the pace of ground involvement. This presentation will review the state of the art in small instruments and science operations in the context of reconnaissance mission concepts for the Human exploration of near earth asteroids and Mars' moons and environment. Acknowledgements: Part of this work is being developed at the Jet Propulsion Laboratory, California Institute of Technology, under contract to NASA. The Hedgehog project is supported by NASA's Center Innovation Fund.

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Robotics

Optimizing Decadal And Precursor Science At Phobos With Spacecraft/Rover Hybrids

We present a mission architecture to address both high-priority science identified for Mars_ moons and strategic knowledge gaps for the future Human exploration in the Martian system. The basic architecture involves a mother spacecraft and one or several minimalistic in-situ mobility platforms, called spacecraft/rover hybrids, first studied under the 2011 NASA Innovative Advanced Concepts (NIAC) program.The mission aims at exploring the surface of Phobos in proximity to the Stickney crater. This region is of particular interest for several reasons. First, previous missions have identified spectral similarities between some terrains in the Stickney region and C-type asteroids, i.e., asteroids that are believed to be rich in water and organics and related to carbonaceous chondrites. Besides, this area displays a large complexity in terms of terrain properties, variations in regolith color, mass wasting, ejected blocks, etc., which makes it a particularly interesting exploration target. In order to explore these different terrains, one needs a mobility platform that can both achieve a spatial coverage of a few kms and access discrete and narrow areas through fine mobility. This is particularly difficult due to the very low gravity environment, which challenges traditional forms of mobility such as wheeled or legged platforms. In our mission architecture, this capability would be provided by the aforementioned hybrids, which are minimalistic platforms employing an innovative mobility mechanism and carrying a suite of instruments complementing those on the mother spacecraft (which would act as a communication relay to Earth and perform remote measurements). Specifically, a spacecraft/rover hybrid is a multi-faceted geometric solid that encloses three mutually orthogonal flywheels and is surrounded by external spikes. The combination of the actuation of the flywheels with the enclosure_s and spikes' geometry would enable controlled tumbles (for fine mobility) and hops (for large surface coverage). This mobility concept has been validated on a number of microgravity test beds at JPL and Stanford, and has been recently selected for further validation on NASA's parabolic aircraft flights. The current state of miniaturized instrumentation allows the accommodation of several geophysical instruments and one analytical instrument within the hybrids, which, in conjunction with a stereo camera and a dust analyzer on the mothership, could provide key information about the physical properties and composition of the surface. Accordingly, a fundamental aspect of this architecture is that the responsibility for primary science would be shared between the mothership and the hybrids. The mothership would provide broad area coverage, while the hybrids would zoom in on specific areas and conduct in-situ measurements.

Author: TED ROUSH
POSTER

Robotics

Exploring in the Dark

In low light level environments (LLEs) on Earth, humans typically provide sufficient, if not excessive, illumination via abundant energy sources. Planetary surface rovers have extensively explored exclusively in the sunlight. However, robotic exploration in LLEs of interest to resource potential, e.g. permanently shadowed regions at lunar poles, or biologically protective environments, e.g. lava tubes and other caves, share a common characteristic; abundant energy is seldom, if at all, available. Anyone that has traveled in the dark is aware of how their perception of their surroundings is driven by their illumination source. We discuss the potential impact on science operations and understanding that occurs while operating a rover in LLEs.

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Robotics

PlanetVac: Pneumatic Sample Acquisition and Delivery System for Asteroids

One of the hardest things to do in planetary exploration, but one of the most valuable, is to sample a planetary surface – gather planetary regolith – and then transfer it to a science instrument or sample return capsule. Current ways to do that, such as robotic arms, are costly and complex with lots of moving parts. PlanetVac, which stands for Planetary Vacuum, is a concept that effectively blows material up tubes using compressed gas provided from the pressurant tanks or dedicated tanks. The PlanetVac sampling devices is built into the lander legs to eliminate costly deployment from the lander deck to the ground. This technique can be used to feed regolith, including small rocks, to science instruments and/or feed it into sample return rockets on landers on Mars, asteroids, or the Moon. Because of the low pressures on all those bodies, the technique is extremely efficient; the efficiency is related to the ratio of the exit gas pressure to the ambient pressure (or vacuum).
To demonstrate this approach, PlanetVac lander with four legs and two sampling tubes has been designed, built, and tested. Testing has been performed in vacuum chamber and with two planetary simulants: Mars Mojave Simulant (MMS) and lunar regolith simulant JSC-1A. One sampling system was connected to an earth return rocket while the second sampling system was connected to a deck mounted instrument inlet port (clear box for easy viewing). Demonstrations included a drop from a height of ~50 cm onto the bed of regolith, deployment of sampling tubes, acquisition of regolith into an instrument (sample container) and the rocket, and the launch of the rocket. In all tests, approximately 20 grams of sample has been delivered to the regolith box and approximately 5 grams of regolith has been delivered into a rocket. The gas efficiency was calculated to be approximately 1000:1; that is 1 gram of gas lofted 1000 grams of regolith. PlanetVac video can be watched here: https://www.youtube.com/watch?v=DjJXvtQk6no